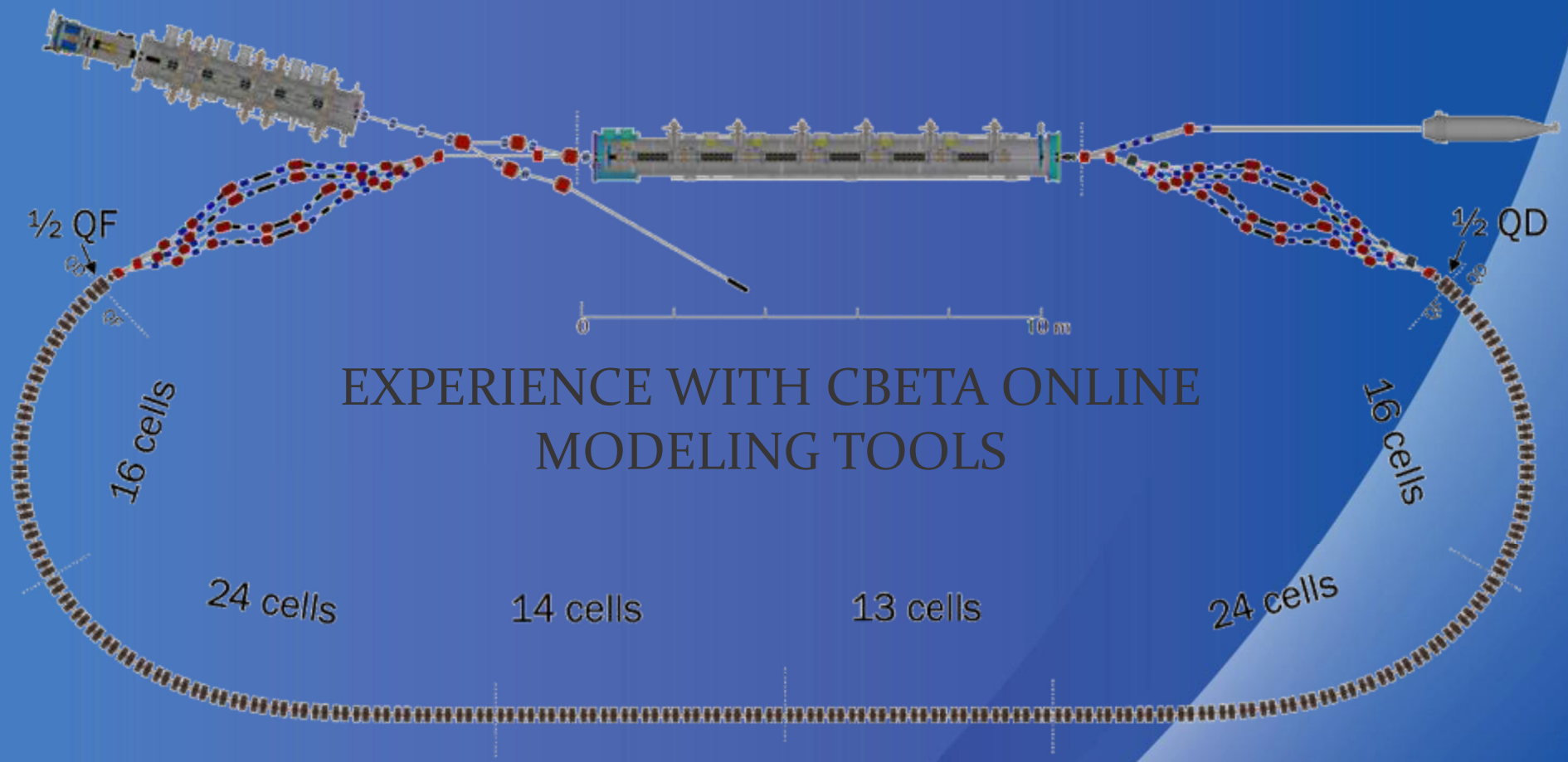

EXPERIENCE WITH CBETA ONLINE MODELING TOOLS

Colwyn Gulliford, Dave Sagan, Adam Bartnik, Scott Berg,
John Dobbins, Antonett Nunez-delPrado

BROOKHAVEN NATIONAL LABORATORY
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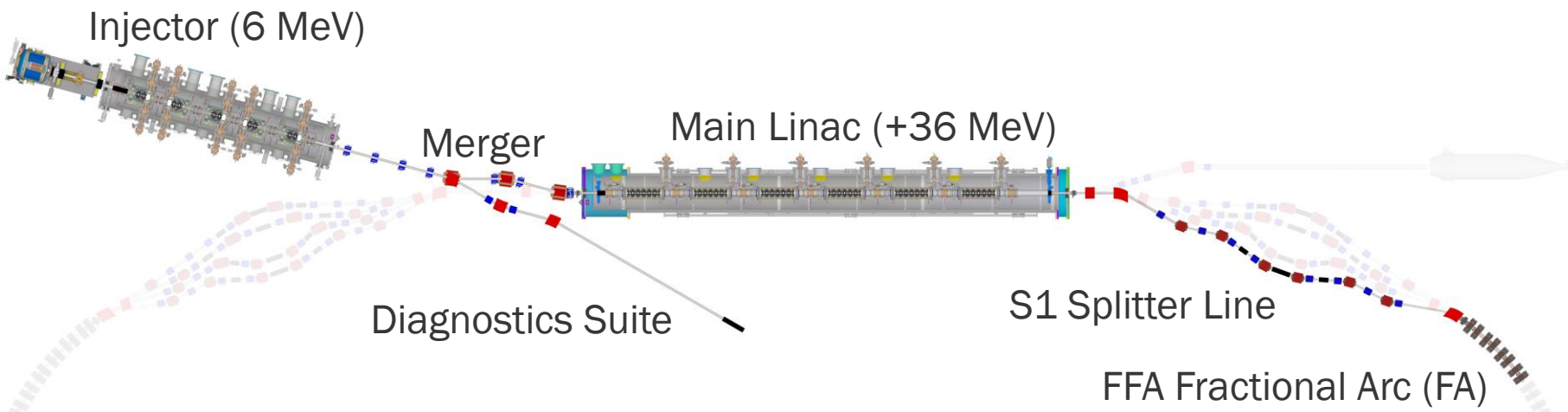
Office of Science
U.S. DEPARTMENT OF ENERGY

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

CBETA: Fractional Arc Test Layout



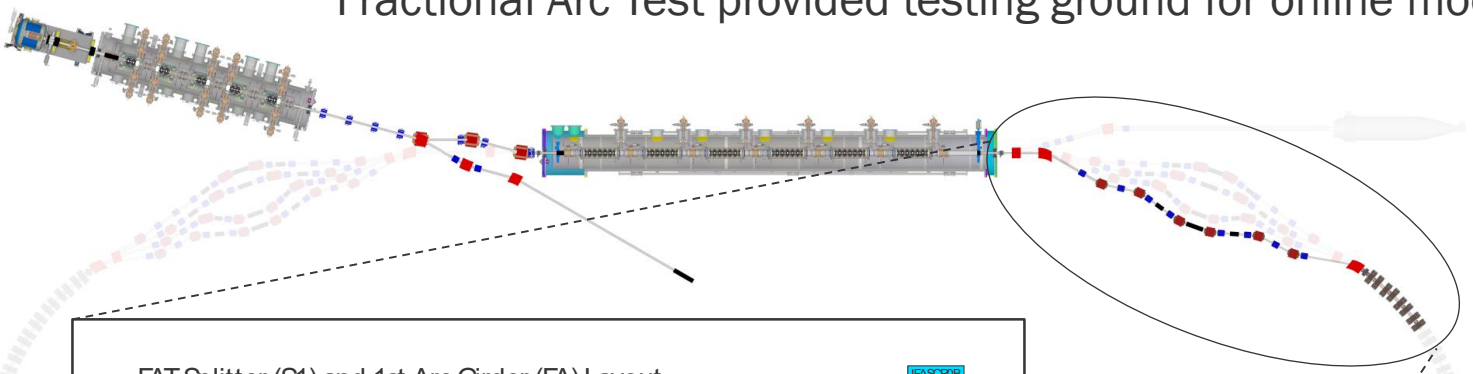
Modeling:

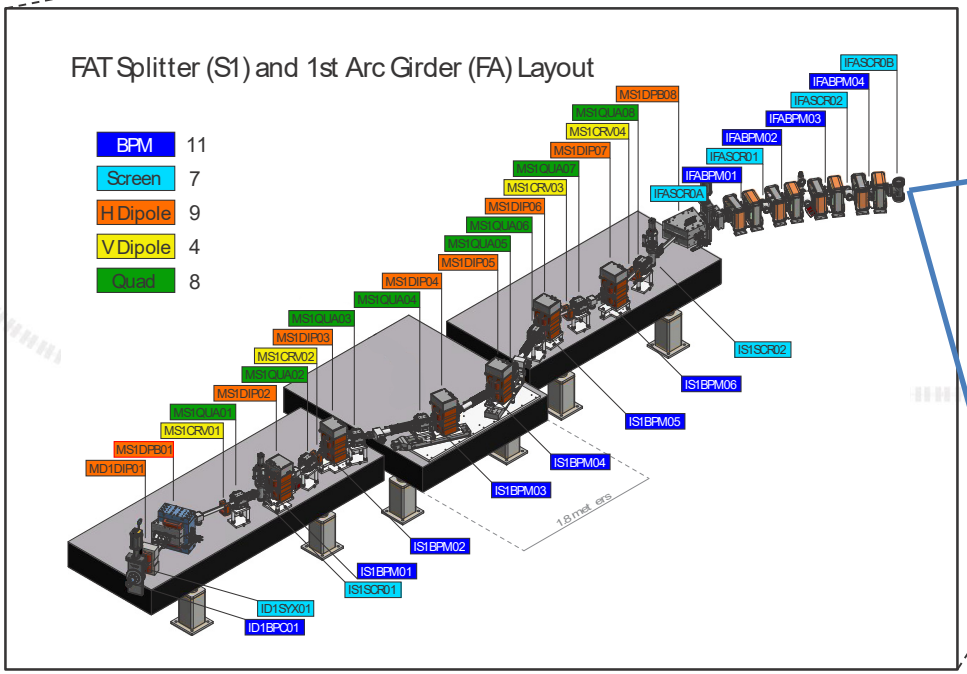
1. GPT for Injector through Main Linac (Space Charge @ E < 42 MeV)
2. BMAD/TAO afterwards (or for strictly single-particle effects everywhere)
3. CBETA-V online model(s)

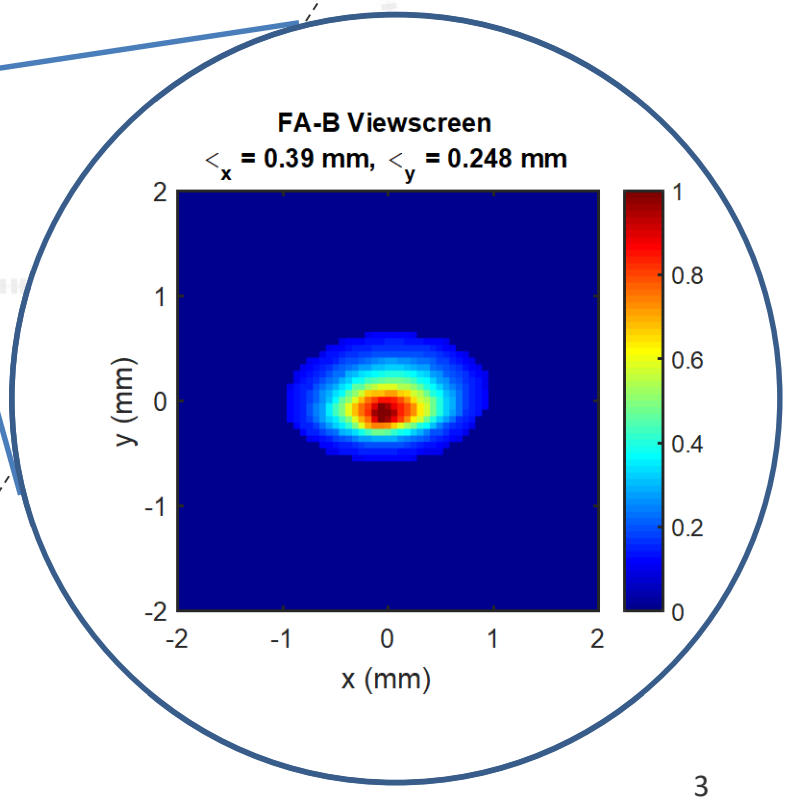
42, 78, 114, 150 MeV

Beam to end of Fractional FFA Arc @ 42 MeV April 2018

Fractional Arc Test provided testing ground for online models







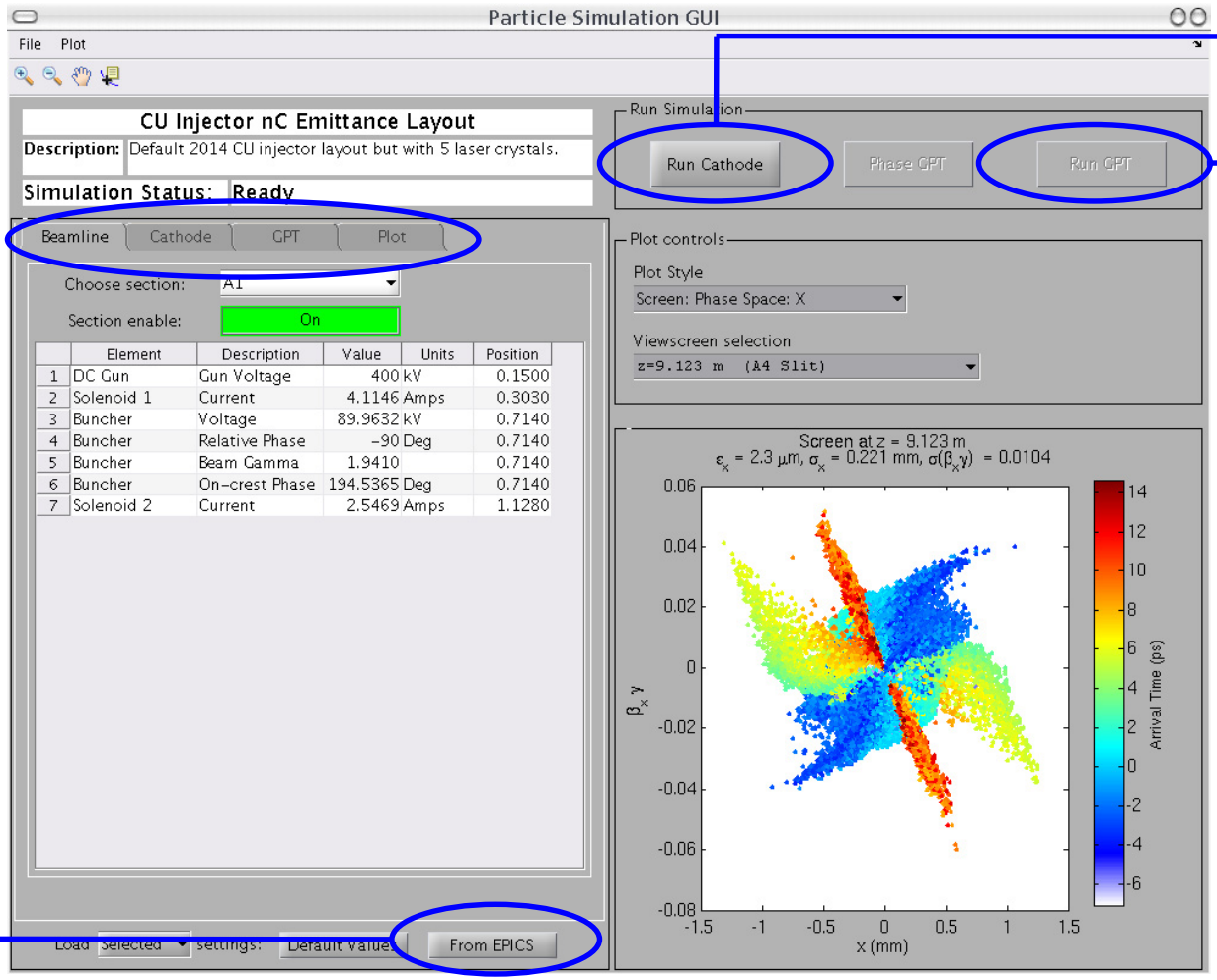
GPT Online Injector & Linac Model (E ≤ 42 MeV)

Save / Load from file or optimizer

Control Tabs

Beamline Settings

Load from EPICS

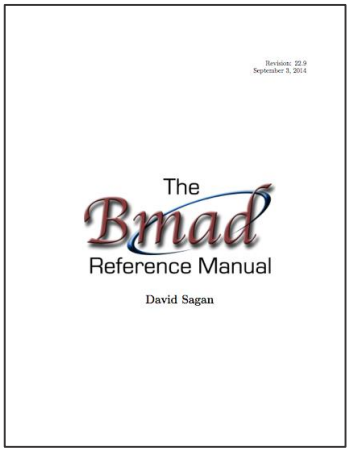


Create Particles

Run GPT

Plotting + Analysis

- Fortran 2008, O^2 , Interface to C++
- Bmad can be run multi-threaded (w/few restrictions).
- Lattice files use a MAD like syntax.
- Well documented (Manual is ~500 pages).

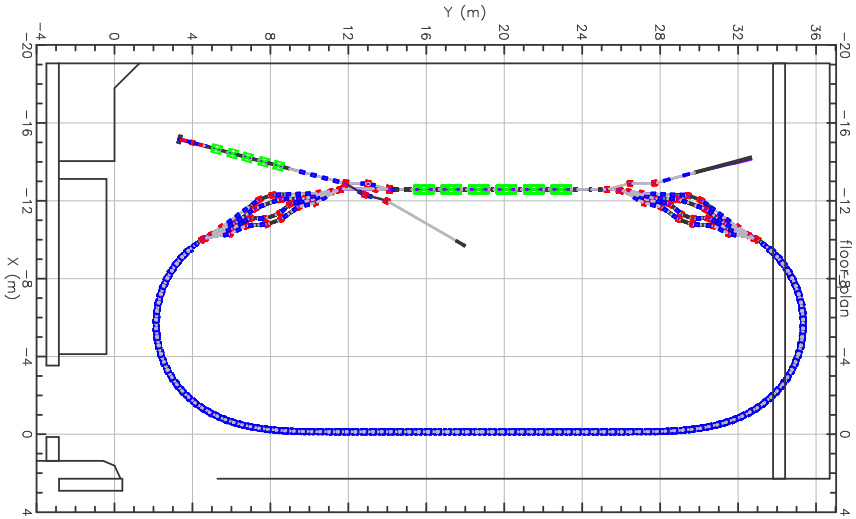


http://www.lepp.cornell.edu/~dcs/bmad/

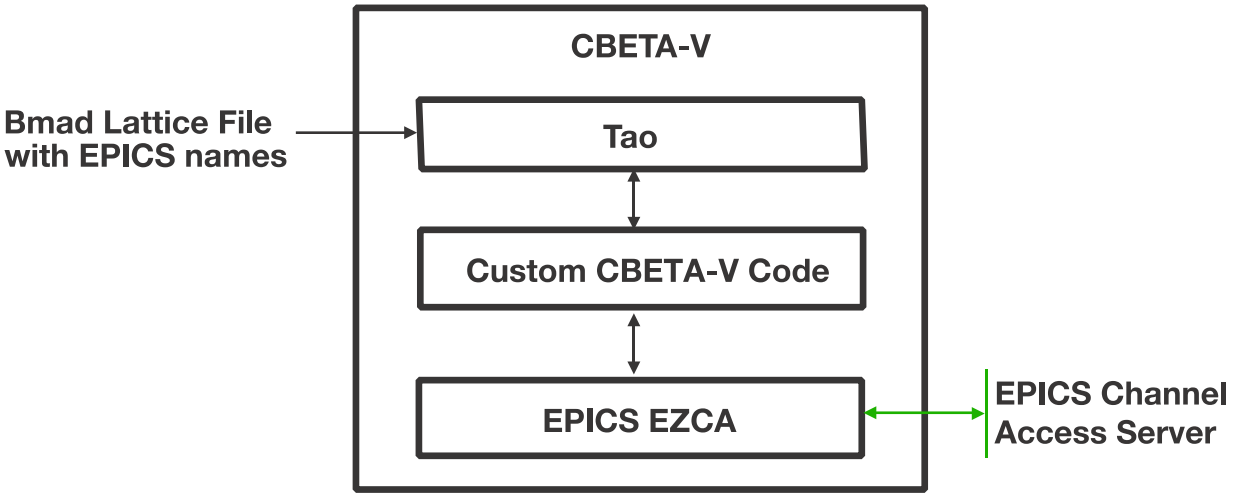
Executable: Tao - a general purpose simulation & design program with
- Twiss and orbit calculations.
- Nonlinear optimization.
- Analysis of complicated geometries.
- Etc.

- Tao's object oriented coding makes it easy to extend:
  >> Add custom commands to interface Tao with a control system.

CBETA Layout in TAO



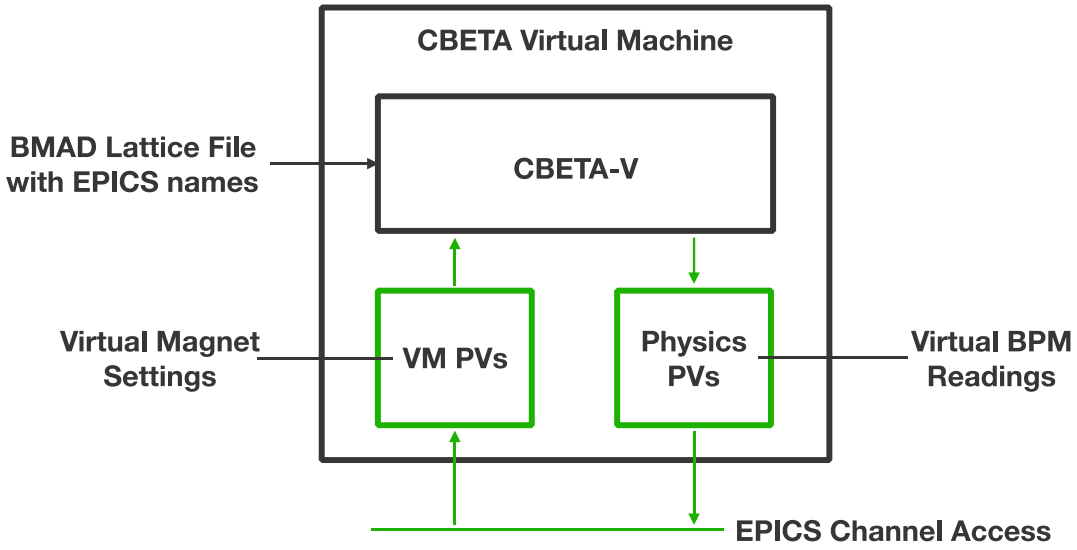
- Incorporates *all* TAO capabilities: perfect for those familiar with TAO
- (Minimal) Custom code auto generates relevant variables/objectives for optimization
- Handles TAO <-> EPICS book keeping
- EPICS get/put via linking to EPICS EZCA
- Communication with EPICS -> get Save/Restore for free



- All conversion data stored in EPICS records:

Lattice Element
- ELEMENT_POWER_SUPPLY_[CMD, RDBK] [Amps, Volts, etc]
- ELEMENT_FIELD_SCALE [Tesla/Amp, etc]
- ELEMENT_FIELD [Tesla, etc]

- Python wrapper around CBETA-V
- Creates a clone of the CBETA EPICS control/diagnostic PVs
- Sync mode: monitor CBETA settings, serve up-to-date simulation data
- Good for operators or those less familiar with TAO

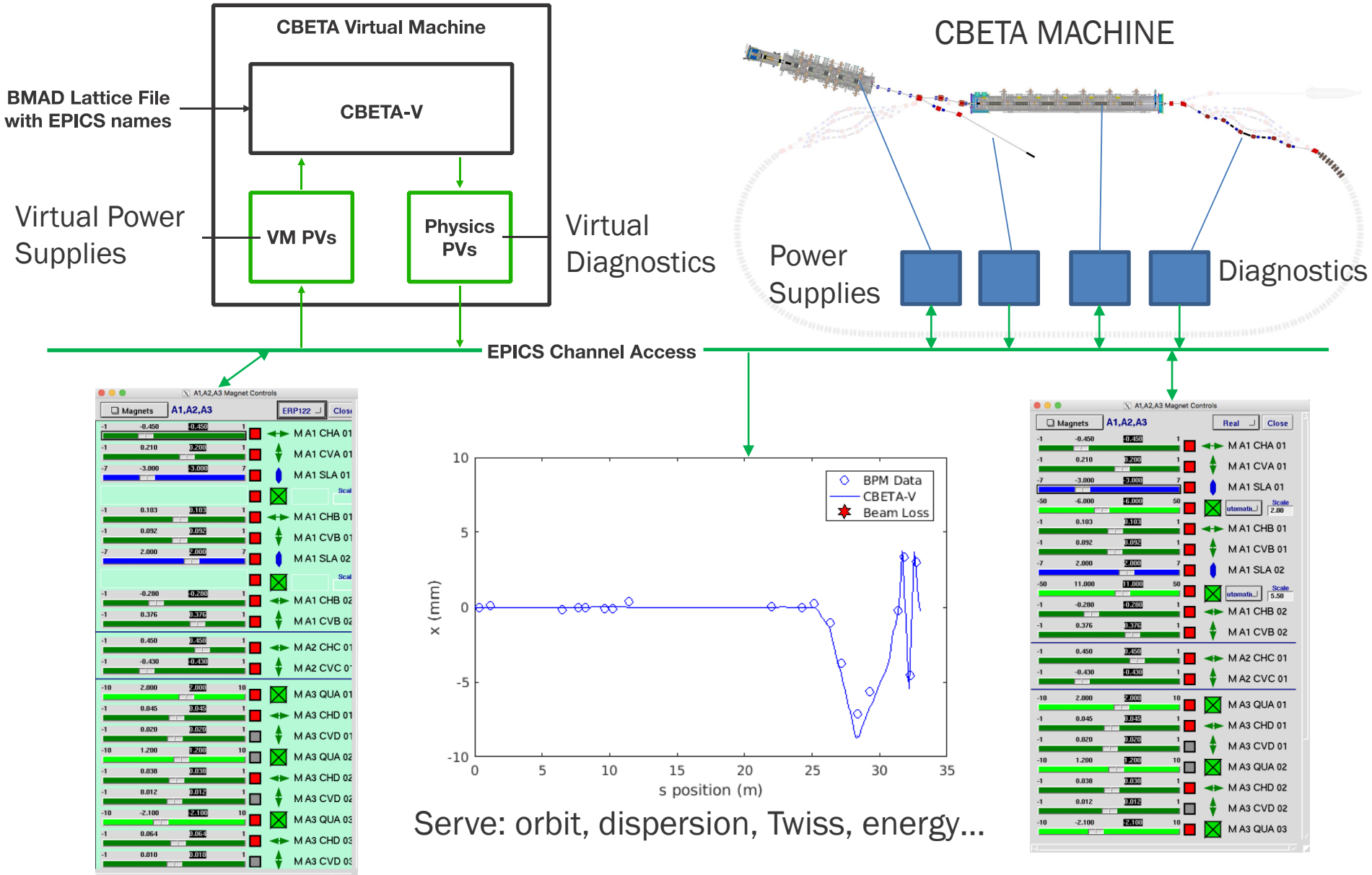


- Serves additional lattice data to EPICS:

Lattice Element
- ELEMENT_s [m]
- ELEMENT_L [m]
- ...

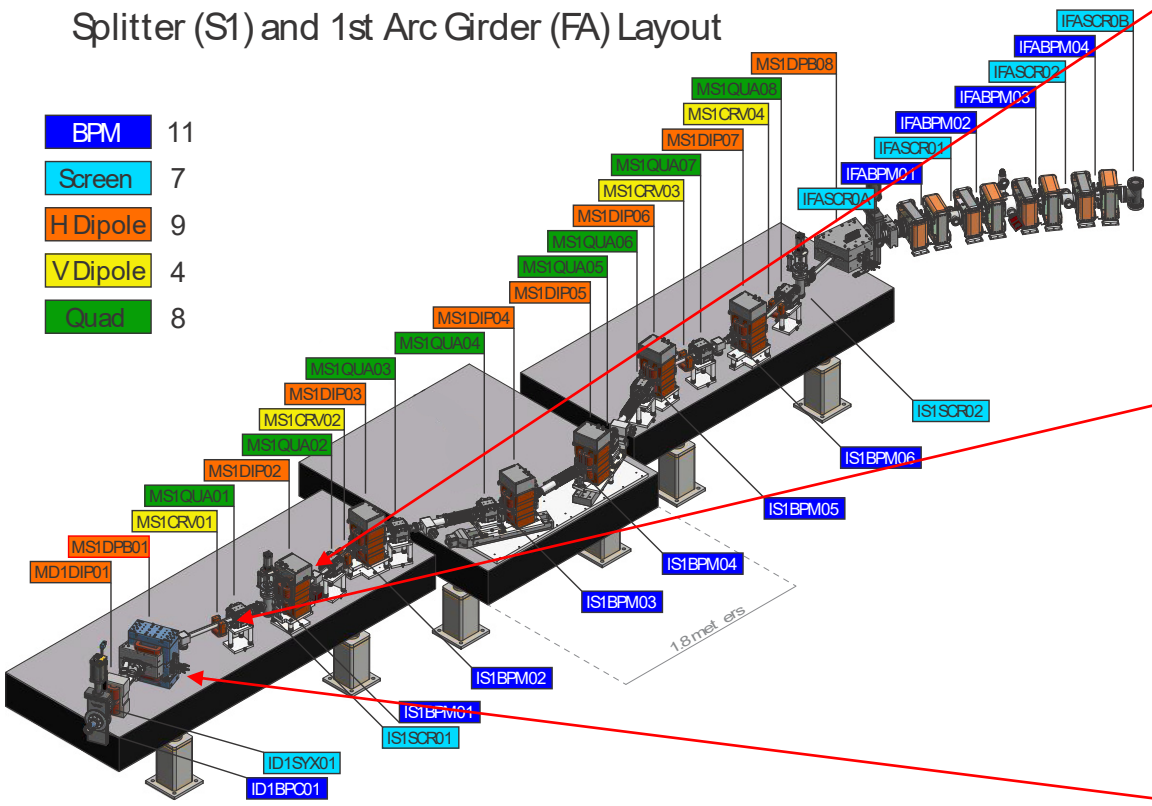
- Can send any TAO command via EPICS, results served as a string

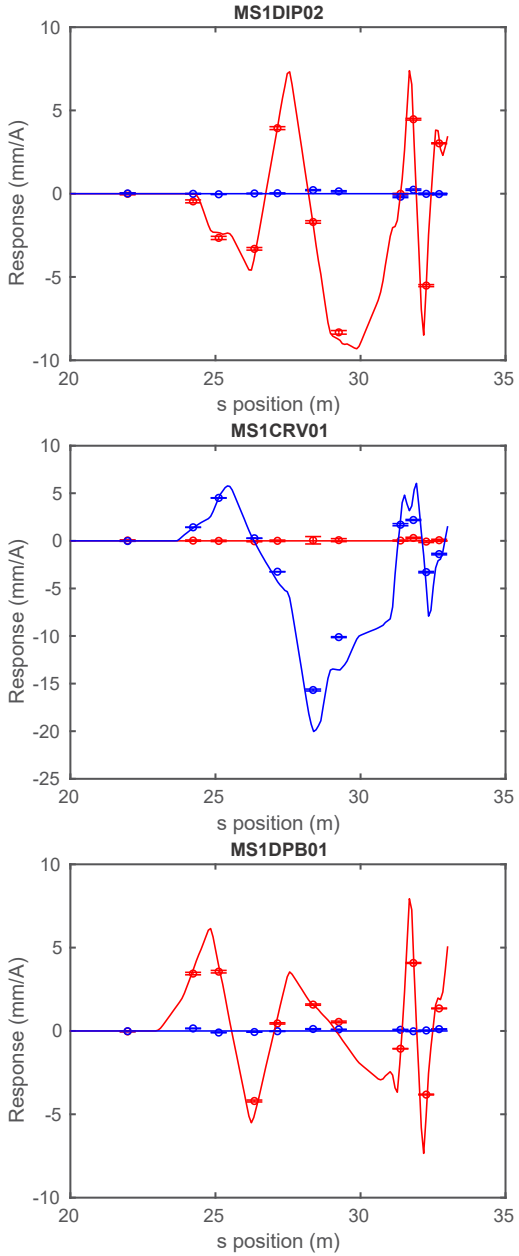
CBETA-Virtual Machine: Real Time Comparison to Data



Orbit Response (42 MeV)

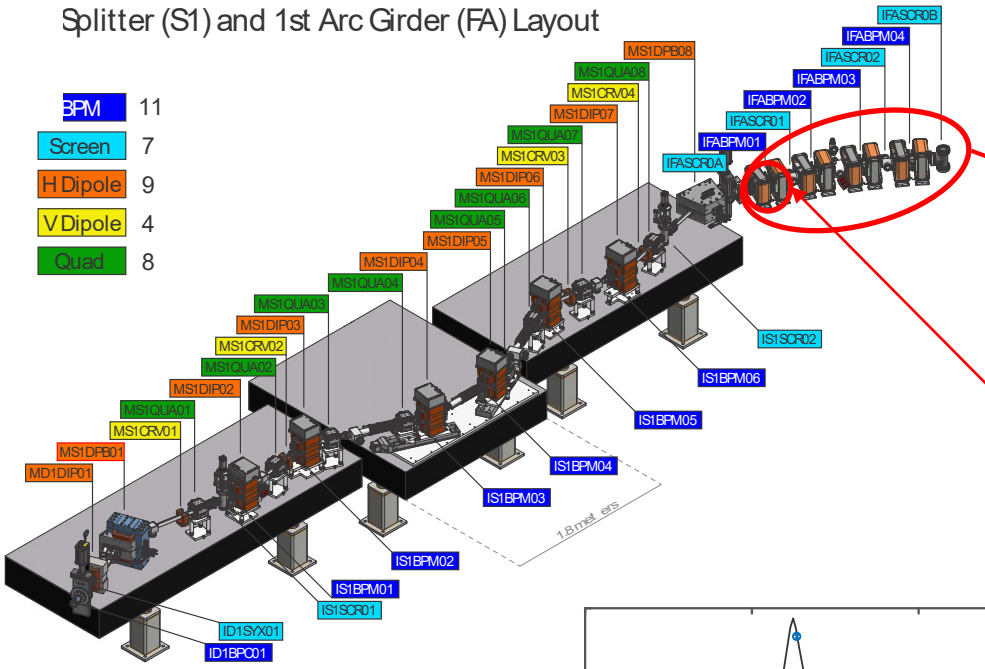
Nice way to verify online model/magnet calibrations

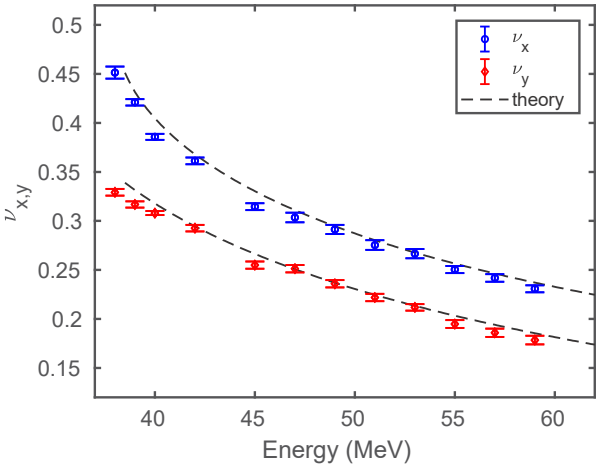


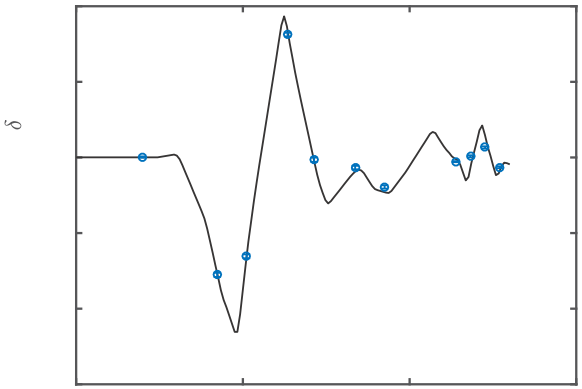


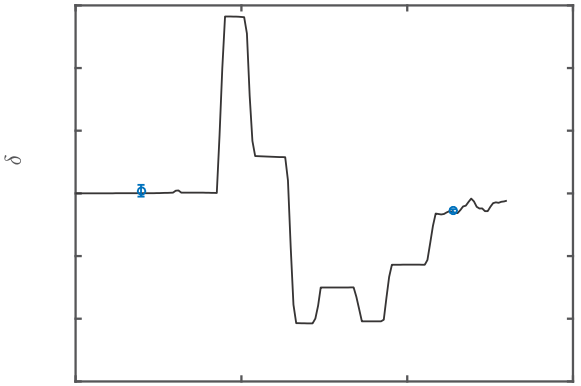
Dispersion & R56, and Tunes Per Cell vs. Energy

Verifying import optics function as a function of Energy…





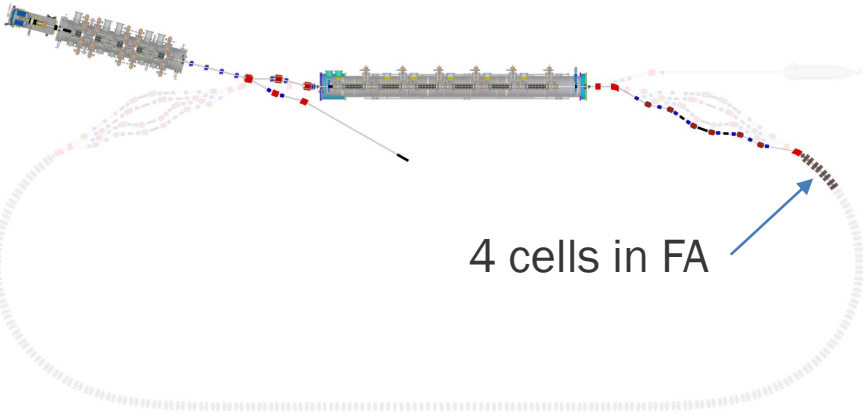


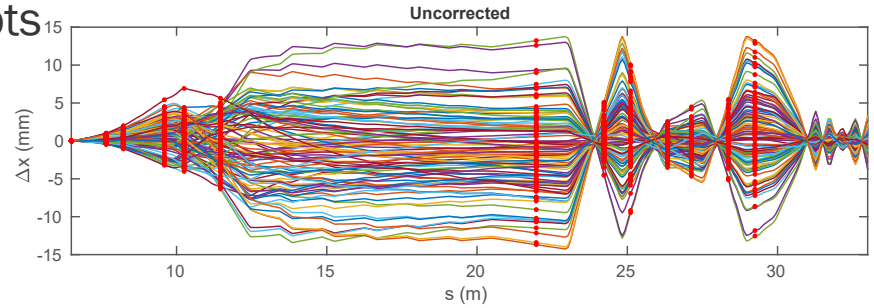


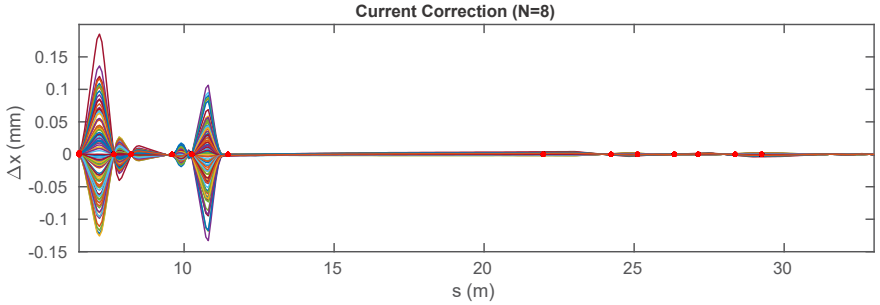
Testing (Virtual) Orbit Correction

Realistically test measurement/optimization scripts

- CBETA-VM serves response matrix/derivatives to EPICS
- Can add realistic errors/offsets to simulation online
- Test SVD orbit correction



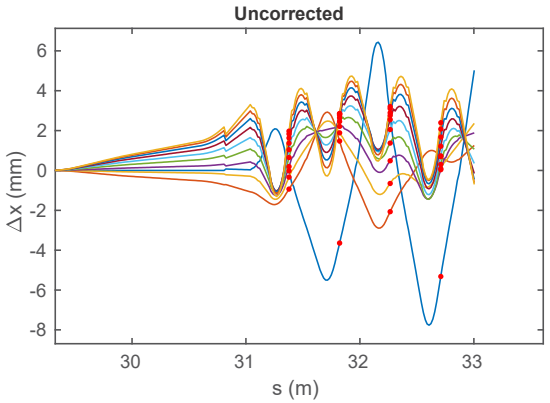


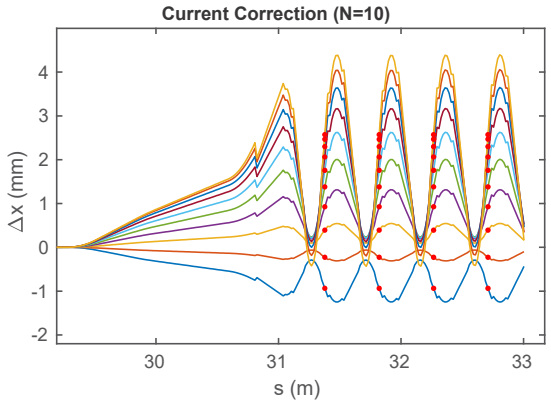


Steering onto periodic orbit at different energies (also SVD)

Inject into FFA at 10 energies 39 – 59 MeV, Initial orbit not periodic

Periodic Orbit <-> BPMs read same value





Conclusion

- Developed Online Model(s) : CBETA-V
  - Based on BMAD/TAO
  - Links to EPICS (EZCA)

- CBETA Virtual Machine
  - Combines CBETA-V + CBETA EPICS records
  - Controlled in the same way as CBETA machine
  - Real time / online data comparison (real time orbit bump)
  - Easy comparison data analyzed offline (orbit response, dispersion, R56, tunes)
  - Testing/Debugging real measurement procedures (orbit correction)

- Future Work
  - Just added 1-pass CBETA Lattice
  - Test realistic orbit correction schemes *before* next commissioning period
  - Generalize VM for other simulation tools & machines (TAO, GPT, … / CESR, BBL)
  - Planned for continued use in CBETA project

Acknowledgements

Fellow contributors: Dave Sagan, Adam Bartnik, Scott Berg, John Dobbins, Antonett Nunez-delPrado

CBETA collaborators:

G.H. Hoffstaetter, D. Trbojevic, N. Banerjee, J. Barley, I. Bazarov, A. Bartnik, J. S. Berg, S. Brooks, D. Burke, J. Crittenden, L. Cultrera, J. Dobbins, C. Franck, R. Gallagher, M. Ge, B. Heltsley, J. Jones, D. Jusic, R. Kaplan, D. Kelliher, V. Kostroun, B. Kuske, Y. Li, M. Liepe, C. Liu, W. Lou, G. Mahler, M. McAteer, F. Meot, R. Michnoff, M. Minty, R. Patterson, S. Peggs, V. Ptitsyn, P. Quigley, T. Roser, D. Sabol, D. Sagan, J. Sears, C. Shore, E. Smith, K. Smolenski, P. Thieberger, S. Trabocchi, J. Tuozzolo, N. Tsoupas, V. Veshcherevich, D. Widger, G. Wang, F. Willeke, W. Xu

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